doi:10.1111/disa.12120

Local perception of infrequent, extreme upland flash flooding: prisoners of experience?

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The United Kingdom has experienced several exceptional summer flash floods in recent years and there is growing concern about the frequency of such events and the preparedness of the population. This paper uses a case study of the upper Ryedale flash flood (2005) and questionnaire and interview data to assess local perceptions of upland flash flooding. Experience of a major flash flood may not be associated with increased flood risk perception. Despite local residents' awareness of a trend towards wetter summers and more frequent heavy rainfall, the poor maintenance of rivers was more frequently thought to be a more significant factor influencing local flood risk than climate change. Such findings have important implications for the potential success of contemporary national flood policies, which have put greater emphasis on public responsibility for responding to flooding. This study recommends, therefore, the use of fresh participatory approaches to redistribute and raise awareness of locally-held flood knowledge.

Keywords: flash flood, flood risk management, hazard perception, heavy rainfall, upper Ryedale flash flood, uplands

Introduction

Flooding and flash flooding in the UK

Flooding is a significant natural hazard in England, threatening one in six properties (Environment Agency, 2009). There is evidence that 'large' floods have increased since the mid-1980s in Europe (Kundzewicz, Pińskwar, and Brakenridge, 2013), and flood losses of the magnitude experienced by Europe in 2013 are projected to occur more frequently in the future (Jongman et al., 2014). The United Kingdom has experienced extremely wet weather in recent years (Met Office, 2012a, 2014), and has suffered several exceptional summer floods since 2000 (see Figure 1a), including surface water flooding in lowland urban areas, such as in Hull in June 2007 (Environment Agency, 2007), and rural flash floods, such as in Boscastle, Cornwall in August 2004 (Burt, 2005), in Helmsley and upper Ryedale, in North Yorkshire in June 2005 (Wass, Faulkner, and Curini, 2008), and in Alston, Cumbria in July 2007 (*Cumberland & Westmorland Herald*, 2007). Summer 2012 saw a number of floods (BBC News, 2012a, 2012b; Nugent, 2012).

Disasters, 2014, 39(3): 546–569.
Published by John Wiley & Sons Ltd, 9600 Garsington Road, Oxford, OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

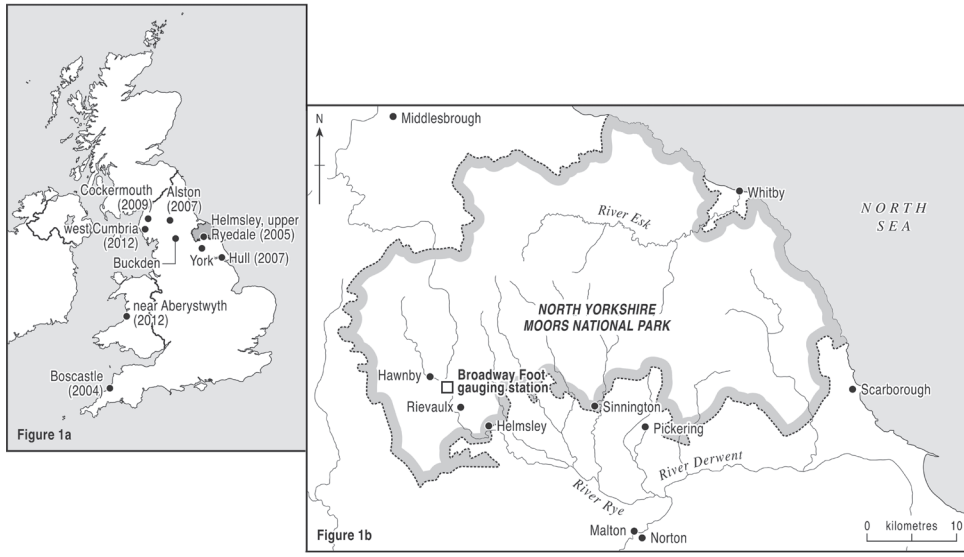
The flash floods described are particularly significant, as such events occur in an unpredictable and sudden fashion (Gruntfest and Handmer, 2001), typically affect small spatial areas (Merz and Blöschl, 2003), and pose a major threat to people (Gruntfest and Handmer, 2001), as evidenced by higher average mortality rates for flash floods as compared to other types of floods (Jonkman, 2005). The UK lacks a nationwide warning system for these floods (Cave et al., 2009), underscoring the vulnerability of individuals and communities to these extremely dangerous events.

Flood policy change and the importance of risk perception research

Since the turn of the century, the need to 'live with rivers', owing to the inability to prevent all floods, and to consider management options other than engineered flood defences (Institution of Civil Engineers, 2001), have been acknowledged and reflected in English flood policy (*Making space for water*; see DEFRA, 2005). A policy shift towards flood risk management has occurred in England and Wales (Penning-Rowsell, Johnson, and Tunstall, 2006), and raising flood awareness and increasing property-level protection against flooding are central components of recent management strategies in England (Environment Agency and DEFRA, 2011) and Scotland (Scottish

Figure 1. Key locations

Figure 1a: floods and other locations mentioned in the paper
Figure 1b: the main settlements and rivers in the area of the North Yorkshire Moors



Notes: the National Park boundary indicates the location of the study area. Flood references as specified in the text, as well as west Cumbria 2012 (Nugent, 2012) and near Aberystwyth 2012 (BBC News, 2012a). Other locations provide geographic context.

Sources: flood information as specified in the text. Contains Ordnance Survey data © Crown copyright and database right 2013. License: Ordnance Survey OpenDataTM License (the most recent version as of May 2014: https://www.ordnancesurvey.co.uk/docs/licences/os-opendata-licence.pdf). Maps produced by the Cartographic Unit, Department of Geography, Durham University.

Government, 2011). Moreover, private modification of buildings can reduce flood damage considerably (Kreibich et al., 2005; Thurston et al., 2008).

A major consequence of these policy changes is that the public now has to assume greater responsibility for managing risks (Penning-Rowsell, Johnson, and Tunstall, 2006; White, Kingston, and Barker, 2010; Environment Agency and DEFRA, 2011). It is of concern, therefore, that awareness of flood risk is only moderate (55 per cent) among those living in flood risk areas of England and Wales (cited in Environment Agency, 2009; see also Fielding, 2012). Furthermore, it has been claimed that some members of the public deny flood risk (Borrows, 2006; Burningham, Fielding, and Thrush, 2008). The acceptance of flood risk by the public is psychologically difficult, although this barrier can be broken down by increased experience of flooding (Harries, 2013).

Risk perceptions are personal 'intuitive risk judgements' (Slovic, 1987, p. 280), which can encompass perceptions of the probability and the consequences of risks (Bubeck, Botzen, and Aerts, 2012). Risk perception also has been conceptualised as the relationship between risk awareness, worry about risk, and preparedness (Raaijmakers, Krywkow, and van der Veen, 2008). In addition to the issues connected to the lack of flood awareness noted above, the understanding of public perceptions of flood risk is critically important. Perception forms an element of the social fabric that contributes to the vulnerability of a location (Cutter, 1996; Cutter, Boruff, and Shirley, 2003) and has been viewed as a key causal factor affecting hazard exposure and poor hazard response (Parker and Harding, 1979). Increased comprehension of risk perceptions could improve understanding of a number of personal decisions and actions (Botzen, Aerts, and van den Bergh, 2009). Conversely, Bubeck, Botzen, and Aerts (2012) note that the associations between risk perception and household flood mitigation found in the literature are, at best, weak, and warn against a policy that overemphasises raising awareness of flood risk; the need to use communications to increase 'coping appraisal'—that is, personal judgements related to undertaking protective measures (see Grothmann and Reusswig, 2006, pp. 104–106)—as well as perceptions has been acknowledged (Grothmann and Reusswig, 2006; Bubeck, Botzen, and Aerts, 2012). Even where individuals perceive there to be a high level of risk, other personal factors, including assessments of risk based on experience, perceived responsibility for responses, and personal circumstances and knowledge of actions, may act as 'intervening variables' and disrupt the perception–action link (adapted from Wachinger et al., 2013, p. 6).

Means of evaluating risk perceptions can be positioned within rationalist or constructivist paradigms (Birkholz et al., 2014), although Kellens, Terpstra, and De Maeyer (2013) point out that many studies of flood risk perceptions have been exploratory and are not theory-based. Notably, multiple literature reviews of flood risk perceptions have been published recently (Bubeck, Botzen, and Aerts, 2012; Kellens, Terpstra, and De Maeyer, 2013; Birkholz et al., 2014), and a sharp rise in the number of publications related to flood risk perception (Kellens, Terpstra, and De Maeyer, 2013) suggests mounting interest in the subject.

Insights gleaned from the literature lead to an expectation that public perceptions of flash flood risks are likely to be low, as a result of flash floods being rare events (Gruntfest and Handmer, 2001; Creutin and Borga, 2003), and the difficulty this poses for preparation (Montz and Gruntfest, 2002). Those with flood experience tend to have a greater awareness/perception of flood risk (Parker and Harding, 1979; Siegrist and Gutscher, 2006; Knocke and Kolivras, 2007; Burningham, Fielding, and Thrush, 2008; Miceli, Sotgiu, and Settanni, 2008; Botzen, Aerts, and van den Bergh, 2009; Bradford et al., 2012; Fielding, 2012; Harries, 2012; Scolobig, De Marchi, and Borga, 2012; Kellens, Terpstra, and De Maeyer, 2013). Residents with flood experience prior to flash flood events (as compared to those without) have been found to have a higher awareness of flooding and a higher perception of future flood risk (Scolobig, De Marchi, and Borga, 2012), and past experience of flooding has been found to be associated with perceived risks of flash floods (Knocke and Kolivras, 2007). Concern about flooding has been found to be correlated with past flood frequency in different areas (Prelog and Miller, 2013), and a higher frequency of floods experienced has been found to be associated with increased negative emotions and health issues owing to stress during the flood season (Hansson, Noulles, and Bellovich, 1982).

Pioneering natural hazards research has identified both the effect of the perceived frequency of flood hazard experience on responses (Kates, 1962; Burton, Kates, and White, 1968) and the concept of the 'prison of experience'. The 'prison of experience' concept is the reflection that expected future flood damages and individual choices of responses to floods are correlated with past experience (Kates, 1962, p. 132). Essentially, past experience will not be useful if floods occur that are different to those experienced in the past (Kates, 1962; Burn, 1999). Green, Tunstall, and Fordham (1991) also describe the 'model' of past flood experience used by individuals to form perceptions of the future, and the tendency of perceptions of the future to reflect closely past experience. The literature suggests that different aspects of experience influence perceptions (Kellens, Terpstra, and De Maeyer, 2013). Wachinger et al. (2013, p. 4) note in their literature review that 'low severity and seldom experienced events can produce a false sense of security/misjudgement of ability to cope'. Furthermore, periods of minor flooding have reduced awareness of the issue at the national level (Kundzewicz, Szamałek, and Kowalczak, 1999). Past experience of flooding, including its 'normal' extent and pattern of occurrence, has been found to be a factor in the low perception of flood risks and the lack of expectation of flooding before a major flood (Burningham, Fielding, and Thrush, 2008), and low perceptions of future flood damages can be linked to experience of minor floods (Botzen, Aerts, and van den Bergh, 2009).

The literature outlined above raises the question of how extreme, but rare, flash floods are perceived by those who are affected by them, in the light of their flood experience. In addition, given the high frequency of recent summer floods in the UK, and the effect of recent policy changes, research on the ways that individuals perceive and respond to extreme flood events is vital. Further research of flash flood perceptions has been identified as important (Knocke and Kolivras, 2007; Cave et al.,

2009). This paper also seeks to satisfy a recommendation for further research on associations between experience and perceptions (Kellens et al., 2013), and aims to contribute to a need for 'a re-invigoration of flood risk perception research' to understand better its relationships with 'the vulnerability, capacity and resilience of individuals and communities in the face of flooding' (Birkholz et al., 2014, p. 18).

There are other reasons why examining *rural* flash floods is particularly important. Notably, rural populations potentially are more vulnerable to floods as compared to urban residents, as they tend to be older and have lower access to services (Twigger-Ross, 2005). Flood policies in England and Wales arguably have adversely affected rural areas, as flood defence funding mechanisms favour urban areas (Johnson, Penning-Rowsell, and Parker, 2007; Environment, Food and Rural Affairs Committee, 2013). Reduced rural dredging and maintenance of rivers also have been noted (Environment Agency, 2007), and the question of the fairness of these policies for rural populations has been highlighted (Whatmore, Ward, and Lane, 2008)—the role of river dredging in flood management is a highly controversial issue following recent floods in England (Bell, 2014; Monbiot, 2014).

Furthermore, the use of natural flood management approaches, which include rural land management techniques (Pescott and Wentworth, 2011), is supported at the strategy level (Environment Agency and DEFRA, 2011; Scottish Government, 2011). Research has found a range of 'barriers', affecting farmers' decisions to install natural flood management measures (Holstead and Kenyon, 2011). Environmental issues are perceived and understood within a local social context (Irwin, Simmons, and Walker, 1999; Bickerstaff and Walker, 2001).

With these wider policy changes and debates in mind, this paper explores public perceptions of factors that affect flooding in rural areas. The upper Ryedale flash flood serves as a case study (see below) of an intense summer rainstorm that caused a dangerous flood in a rural area without a history of frequent large floods and without flood defences or warning systems. This paper aims to address the matter of how residents affected by an extreme flash flood perceive these events, and local flood risks more broadly, and how residents' experience and knowledge of flooding affect their perceptions.

Case study: the upper Ryedale flash flood

The flash flood that forms the focus of this paper occurred in northern England on 19 June 2005, affecting settlements on the upper River Rye, including Hawnby, Helmsley, and Rievaulx (see Figure 1b). The population of Helmsley parish was 1,559 in 2001 (cited in North Yorkshire County Council, 2005). Helmsley is situated downstream of a catchment ('upper Ryedale') of 210 square kilometres. The River Rye is a tributary of the larger River Derwent (see Figure 1b). In three hours on 19 June 2005, 69.4 millimetres of rain fell at Hawnby (Environment Agency data, cited in Met Office, 2005), causing the River Rye to rise by three metres in one hour at Broadway Foot near Hawnby (Wass, Faulkner, and Curini, 2008) (see Figure 1b).

Figure 2. Flood damage at Hawnby

Source: author (Jeff Warburton).

The flood caused an estimated GBP 1.1 million of damage to 32 properties in Hawnby, Helmsley, and Rievaulx, and destroyed or damaged three road bridges (Wass, Faulkner, and Curini, 2008) (see Figure 2). Personal communications with local residents highlighted the extreme nature of the flood, which resulted in emergency rescues, residents being displaced from their houses for several months, a depressed local economy, insurance problems, and stress and illness.

Methodology

Primary data collection for this study involved two main methods: (i) semi-structured interviews in Hawnby, Helmsley, and Rievaulx; and (ii) a postal questionnaire survey, distributed to all addresses in Helmsley. The area inundated during the 2005 flash flood was identified using post-flood survey data (survey by the Environment Agency), and 40 potentially affected properties were pinpointed. Interviews were thought to be an appropriate method of data collection, given the fairly small number of affected properties (also noted in Wass, Faulkner, and Curini, 2008). Following initial contact via letter and subsequent telephone contact with those who returned a reply slip, 14 interviews were held between July and October 2008 with 19 people, 12 of whom lived in nine houses directly affected by flash flooding (where property was damaged, following the definition of Penning-Rowsell and Chatterton, 1977). Interviews took place within the homes of interviewees and lasted for an average of 39 minutes, and covered a range of topics, exploring perceptions, experiences, and responses to flooding. Parts of the transcript text relevant to research objectives were

identified and extracted. While the interview method can effectively gather rich data, the nature of interview samples means that findings cannot be easily generalised (Boyce and Neale, 2006). A questionnaire survey, a method 'more likely than some other approaches' to collect data that can be generalised (Kelley et al., 2003, p. 262), thus was used to quantify and assess qualitative findings.

Preliminary interview findings and a literature review influenced the questionnaire design, which, after piloting, was distributed to 841 addresses (all identified addresses in Helmsley, the largest settlement in upper Ryedale affected by flash flooding) in spring 2009. One hundred and fifty-six questionnaires were returned and used in the analysis, forming a self-selecting sample. The response rate (18.5 per cent) is close to the typical 20 per cent response rate for postal questionnaires (cited in Kelley et al., 2003), and is similar to or greater than response rates recorded in other natural hazard studies that used postal surveys (23 per cent in Ludy and Kondolf, 2012; 17.3 per cent in Prelog and Miller, 2013; and 7.3 per cent in Manock et al., 2013). However, this study does not claim that the survey dataset analysed is representative of the local population. Rather, it contends that the sample, when analysed alongside qualitative data, produces a highly useful dataset in the context of the small areas typically affected by flash floods (see, for example, Gruntfest and Handmer, 2001).

A comparison of the questionnaire sample with 2011 Census data available from the Office for National Statistics website[1] for the population of the Helmsley electoral ward finds that the questionnaire sample (median age=67, n=105 respondents provided their age) is older than the Helmsley ward as a whole (median age of population 18 years or older=56, n=2,592). The questionnaire sample has an approximately even gender split (male=56.3 per cent, n=144), although the sample is 'more male' than that of the Helmsley ward (male=49.3 per cent, n=3,066). Given the role of flood and hazard experience in affecting perception and awareness, the dataset benefits from capturing a sample with a wide range of broader local experience (years lived in Ryedale: median=20 years, interquartile range=36 years, n=139).

The questionnaire collected information that was sorted into seven categories of variables: flood risk perception (dependent variables); demographic characteristics of respondents; location of respondents' houses; experience of flooding in 2005; overall flood experience; perception of rainfall changes; and responses to the 2005 flash flood (not analysed in this paper) (see Table 1). Questionnaire topics were based on preliminary interview findings: emergent themes and subjects, and insights gained from a literature review carried out during the project; these variable categories also reflect many of the factors associated with risk perception (Kellens, Terpstra, and De Maeyer, 2013, pp. 42–44; Wachinger et al., 2013, pp. 3–5) and flood response (Bubeck, Botzen, and Aerts, 2012, pp. 1489–1490) outlined in more recent literature reviews. Here, risk perceptions are defined as personal views of (i) the nature of the flash flood experienced in 2005, (ii) the likelihood of flooding in future, and (iii) trends in flood patterns (whether flooding was getting worse). These definitions reflect the two components of risk perception, probability and consequences, noted by Bubeck, Botzen, and Aerts (2012, p. 1483).

Table 1. Variables derived from questionnaire dataset for analysis

Category	Variables/attributes: description and values or attribute levels
Flood risk perception	• Perception of flash flood as a one-off event (agree, neither agree nor disagree, disagree). • Perception of likelihood of local (Upper Ryedale (Helmsley/Rievaulx)) flooding in next 10 years (high, medium, low). • Perception of likelihood of flooding in Pickering town centre/central York/own house in next 10 years (three variables) (high, medium, low). • Perception of flooding of the River Rye/other streams in Ryedale/surface water flooding in Ryedale/flooding across the country as a whole (four variables) (agree, neither agree nor disagree, disagree that flooding is getting worse). • Perception that local flooding (Ryedale) will occur more frequently in the future (agree, neither agree nor disagree, disagree).
Demographic	• Age (years). • Years lived in Ryedale (years). • Children living in house (yes, no). • More than one adult living in house (yes, no). • Gender (male, female). • Employment (in work, retired).
Location	• Distance of house from river (metres). • Within flood risk zone 3* (yes, no).
Experience of flooding in 2005	• Affected by Ryedale flood in 2005 (directly affected, indirectly affected, no)**. • Personally witnessed 2005 flood (yes, no). • Knowledge of any person***/friends/relatives/others (friends/relatives/others) directly affected by flash flood (four variables) (yes, no). • Involved in clean-up following flash flooding (yes, no).
Overall flood experience	• Total number of floods recalled (total)****. • Total number of floods recalled in 1990s and 2000s (total)****. • Ever experienced or affected by flooding before 2005 (yes, no). • House affected by surface water flooding before (yes, no).
Perception of rainfall changes	• Perceived wetness of 2000s/1990s/1980s/1970s/1960s/1950s/1940s/1930s (eight variables) (drier than average, about average rainfall, wetter than average). • Perceived trend in winter/spring/summer/autumn rainfall (four variables) (have got drier, no noticeable change, have got wetter). • Perceived change in snowfall/prolonged rainfall/intense, heavy thunderstorms (three variables) (occurring less often, no change, occurring more often).

Notes: variable descriptions are similar but are not the same as question wordings, and some response categories given constitute combined categories. Location variables calculated using GIS (geographic information system). Variables in italics do not refer to local risk perceptions.

Sources: author (Jonathan Hopkins). * Definition in Department for Communities and Local Government, 2006, p. 23; ** Similar definitions to those given in Penning-Rowsell and Chatterton, 1977, pp. 1–2; *** Question asked first, then respondents were asked to specify group if answer was 'yes'; **** Calculated from floods marked on timeline, and other recalled floods.

Questionnaire data analysis (involving Statistical Package for the Social Sciences (SPSS) software) used descriptive statistics and three bivariate tests: the Chi square, the Mann–Whitney U, and the Kruskal–Wallis tests (Pallant, 2013). Significant ($p<0.05$) test results are reported within this paper. Test results for variables relating to perceptions of flood risk outside the local area are not included here, although some descriptive statistics from these data are noted. Odds ratios (OR), a type of risk estimate (Ferguson, 2009), are used to quantify differences in perception between two

groups of respondents, where a valid and statistically significant association was found between categorical variables. They are interpreted based on guidance for social science data provided by Ferguson (2009, p. 533). For Chi square tests, results were removed in cases where more than 20 per cent of cells had expected frequencies below five (violating an assumption of the test—see Freeman and Julious, 2007; Pallant, 2013). Respondents' perceptions of factors affecting flooding were assessed using a study of open responses, given within a box provided for thoughts about flooding more generally and responses to the following questions: 'What factors contributed to the flood in Ryedale in 2005? Has anything occurred to increase the risk of flooding?'.

This paper also includes insights acquired from evaluations of physical data. A composite daily rainfall series for upper Ryedale, running from 1916 to August 2009, was analysed (Hopkins, Warburton, and Burt, 2010). For this study, four months of data was added to expand the series to the end of 2009. Rainfall data used were downloaded from the Met Office Integrated Data Archive System (MIDAS) Land Surface Stations database (Met Office, 2012b). 'Heavy rain days' are defined here as days recording more rainfall than the total exceeded on one per cent of days within the record. This is a modified version of a threshold defined by Karl and Knight (1998).

In addition, gauged river flow data were available from Broadway Foot, situated on the River Rye two kilometres from Hawnby (see Figure 1b). Fifteen-minute interval data were available between 23 August 1977 and the end of 2009 (with some short periods of missing data). This study assesses the 50 largest recorded flow events (lowest peak flow threshold=47.4 $m^3 s^{-1}$ (cubic metres per second)), in terms of peak discharges and the mean rate of discharge increase ($m^3 s^{-1} h^{-1}$, cubic metres per second, per hour). The Environment Agency provided discharge data.

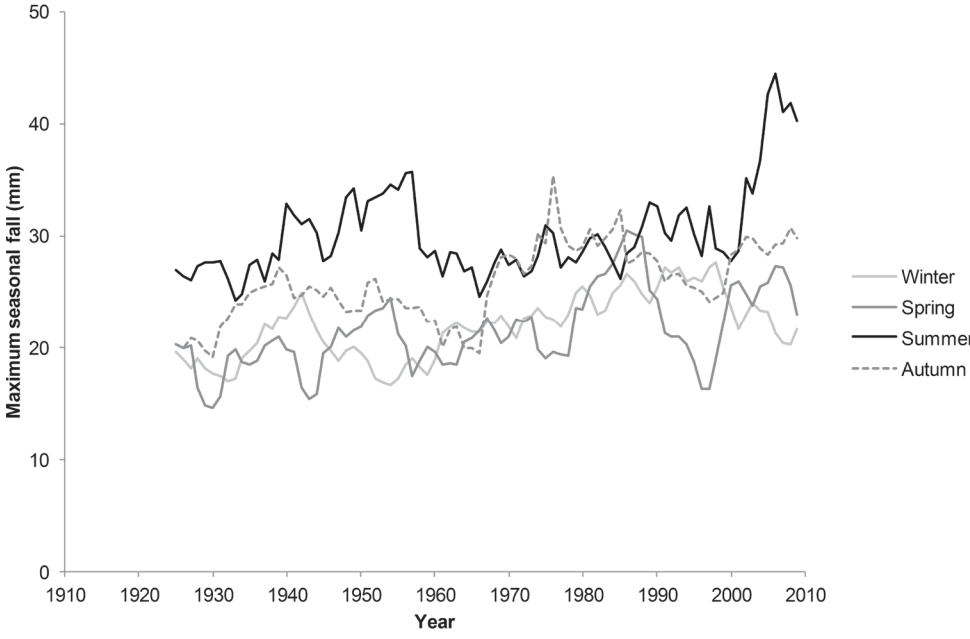
Results

Causes of flash flooding

Flash floods, and the heavy rainfall events that cause them, typically occur in summer (Merz and Blöschl, 2003). An increase in summer heavy rainfall frequently represents, therefore, an increase in flash flood risks. In the uplands of northern England, winters got wetter with a greater frequency of heavy rainfall during the late twentieth century (Burt and Ferranti, 2012). However, an increase in heavy summer rainfall from the 1990s to the 2000s also has been noted, vis-à-vis the frequency of heavy rainfall events (Burt and Ferranti, 2012).

Within upper Ryedale, the proportion of summer rainfall falling on heavy rain days increased after 2000, as did the frequency of heavy rain days in summer. Summers in the 1990s (1991–2000) saw seven heavy rain days, whereas 18 heavy rain days were recorded in the summers from 2001–09. In addition, the maximum daily rainfall recorded in summer sharply increased in magnitude from the late 1990s onwards (see Figure 3): the mean summer maxima rose from 27.8 millimetres (1991–2000) to 41.7 millimetres (2001–09).

Figure 3. Maximum daily rainfall total recorded seasonally at upper Ryedale, 1916–2009



Note: the figure shows ten-year running means.

Sources: author (Jonathan Hopkins); data from Met Office (2012b).

Furthermore, local residents in upper Ryedale are aware of an increase in local rainfall, particularly in summer. Two-thirds of questionnaire respondents viewed the 2000s period as wetter than average (67.2 per cent, n=119), and a similar proportion (66.4 per cent, n=134) believed that summers had got wetter over the years that they had lived in upper Ryedale. The proportions of respondents believing that other seasons (winter, spring, autumn) had got wetter were all below 39 per cent (n=137, n=134, n=134, respectively). Furthermore, 46 per cent of respondents perceived that prolonged rainfall (lasting for more than a day) was occurring more often (less often: 12.9 per cent, n=139), with a respective figure of 40.6 per cent for intense, heavy thunderstorms (less often: 15.9 per cent, n=138).

Open-ended responses to the questionnaire show that, despite the awareness of rainfall changes, residents were more likely to mention (poor) maintenance of rivers and streams (mentioned by 26 per cent of responses) as an issue affecting local flood risks than some aspect of climate change (12 per cent). Fourteen per cent of responses also noted maintenance and issues with ditches and drains. Reference often was made to watercourses not being dredged, or to vegetation not being removed from riverbanks; frequently these were thought to be caused by changing management. Several interviewees also mentioned river maintenance. The following questionnaire extract summarises the issue:

> *As late as the 1980s there were men who worked on the Rye clearing debris, overhanging foliage, weeds etc. although the river used to break into lower lying fields, it was nothing*

unusual. Since the environment agency took control of such waterways, all maintenance seems to have come to a halt. As a result, there is a build-up of rubbish, debris from the 2005 floods, weeds etc., and as a result the river rises very, very quickly with just 'normal rainfall'.

More widely, the public view of poor river maintenance contributing to flood risk has been recorded frequently, such as in flood surgeries and communications with the public after the summer 2007 floods in England and Wales (Environment Agency, 2007). Participatory research within Pickering, North Yorkshire, also revealed such views (Whatmore, Ward, and Lane, 2008; Lane et al., 2011). The widespread flooding that affected parts of England in 2014 led to media coverage of farmers' demands for river dredging (Bell, 2014; Smith, 2014). Following major flooding in Cockermouth, Cumbria in 2009 (see Figure 1a), the chair of the local flood action group spoke of a lack of dredging, possibly owing to wildlife interests (Bunyan and Britten, 2009).

Perceptions of flash flooding and local flood risks: statistical analysis

Table 2 presents an overview of questionnaire responses. A majority of respondents disagreed that the 2005 flash flood was a one-off event; however, the 'one-off' sentiment was found more frequently among interviewed residents whose houses were directly affected by flash flooding. In five of nine interviews, there was agreement that the flash flood was a one-off event. In addition, two other residents who lived on a street affected by flash flooding in Helmsley argued that the flash flood was a one-off event. Forty-seven per cent of questionnaire respondents agreed that local flooding would occur more frequently in the future, although 38 per cent answered

Table 2. Summary of the flood risk perceptions of questionnaire respondents

Statement	Disagree	Neither agree nor disagree	Agree	n
The flood which occurred in Ryedale in June 2005 was a one-off event and will not happen again.	52.6	22.4	25	152
Flooding of the River Rye is getting worse.	28.4	38.5	33.1	148
Flooding from other streams in Ryedale is getting worse.	18.9	44.6	36.5	148
Surface-water flooding (water running off the land) in Ryedale is getting worse.	10.2	29.3	60.5	147
Flooding in Ryedale will occur more frequently in the future.	14.6	38.4	47	151
Across the country as a whole, flooding is getting worse.	4.1	8.8	87.2	148
Statement	**Low**	**Medium**	**High**	**n**
In your opinion, what is the likelihood that parts of the following locations (Upper Ryedale (Helmsley, Rievaulx)) will experience flooding in the next ten years?	52.8	37.5	9.7	144

Note: all figures (except 'n') are percentages.

Sources: author (Jonathan Hopkins); questionnaire data.

'neither agree nor disagree'. For all sources of flooding, respondents were most likely to agree that surface water flooding was getting worse (agree=61 per cent). And 87 per cent of respondents agreed that flooding was getting worse across the country, as compared to just 33 per cent of respondents who agreed that flooding of the River Rye locally was getting worse.

A more detailed bivariate analysis, including variables describing perceptions of the flash flood and local flood risks (see Table 3), finds a significant difference in dwelling location (the distance of respondents' houses from the River Rye) across groups with different perceptions of the flash flood of 2005 (Kruskal–Wallis test, $\chi^2(2,124)=6.656$, $p=0.036$). Those who agreed that the flood was a one-off event lived closer to the river on average (median=237 metres) than those who disagreed (median=391 metres) or those who responded 'neither agree nor disagree' (median=397.5 metres). There were significant associations between two types of experience with the 2005 flash flood: (i) knowledge of a person directly affected by the flash flood; and (ii) involvement in the subsequent clean-up, and perceptions of the flash flood event (respectively: $\chi^2(2,146)=6.896$, $p=0.032$; $\chi^2(2,147)=7.79$, $p=0.020$). The odds of respondents who knew a person directly affected by the flash flood agreeing that the flood was a one-off event, rather than disagreeing, were more than six times the odds for those who did not know such a person; a strong effect (following Ferguson, 2009). The respective OR between those involved in the clean-up and those not is 3.26, a moderate effect size showing, again, typically lower perceived risk with a form of flash flood experience. Significant associations also were found between involvement in the clean-up and two variables related to perceived trends in local flooding: (i) perceptions of flooding of the River Rye ($\chi^2(2,144)=6.636$, $p=0.036$); and (ii) perceptions of flooding from other streams ($\chi^2(2,144)=12.849$, $p=0.002$). The ORs between those involved in the clean-up and those not involved (comparing numbers that agreed that flooding was getting worse and those who disagreed that flooding was getting worse, for both variables) were both well below one (0.46 and 0.29, respectively—the latter constitutes a moderate effect size ($0.29^{-1}=3.46$)). Therefore, experiences of flash flooding are associated with reduced flood risk perception.

However, there were significant differences in the number of recent floods (those in the 1990s and 2000s) recalled across groups with different perceptions for two variables: (i) flooding of the River Rye (Kruskal-Wallis test, $\chi^2(2,146)=6.975$, $p=0.031$); and (ii) local surface water flooding (Kruskal-Wallis test, $\chi^2(2,145)=10.646$, $p=0.005$). For both types of floods, those who agreed that flooding was getting worse recalled, on average (shown by means and mean ranks), a higher number of recent floods than those who disagreed that flooding was getting worse. Despite these significant results for with knowledge of *recent* floods, no significant, valid test results were found in the analysis for with *overall* flood knowledge (all floods recalled).

It is notable that the majority of demographic variables (age, years lived in the local area, whether children were living in the house, whether more than one adult was living in the house, and gender) produced no significant, valid test results in this study. Three significant associations were found between perception variables and

employment, indicating typically lower perceived risks for those in work as compared to retired people (perception of likelihood of local flooding in the next 10 years (high likelihood/low likelihood) OR=0.44, perception of flooding from other streams in Ryedale (agree/disagree that flooding was getting worse) OR=0.56) and an additional very weak effect (perception of flooding of the River Rye (agree/disagree that flooding was getting worse) OR=1.11). It is possible, however, that this explanatory variable acts as a proxy for age, as there is a significant difference in age between the two groups (U=120, p<0.001).

Table 3. Statistically significant (p<0.05) test results

Perception variable Explanatory variable	df	n	χ^2	p	OR**
Perception of flash flood as a one-off event (agree, neither agree nor disagree, disagree)					
Distance of house from river (scale variable, metres)	2	124	6.656*	.036	
Knowledge of person directly affected by flash flood (yes, no)	2	146	6.896	.032	6.11
Involvement in clean-up following flash flooding (yes, no)	2	147	7.79	.020	3.26
Perception of likelihood of local flooding in the next 10 years (high, medium, low)					
Employment (in work, retired)	2	112	6.988	.030	0.44
Distance of house from river (scale variable, metres)	2	118	7.109*	.029	
Perception of flooding of the River Rye (agree, neither agree nor disagree, disagree that flooding is getting worse)					
Employment (in work, retired)	2	114	14.681	.001	1.11
Involvement in clean-up following flash flooding (yes, no)	2	144	6.636	.036	0.46
Total number of floods recalled in 1990s and 2000s (scale variable, number of floods)	2	146	6.975*	.031	
Perceived trend in winter rainfall (have got wetter, no noticeable change, have got drier over the years that respondent had lived in Ryedale)	4	133	12.664	.013	1.11
Perception of flooding from other streams in Ryedale (agree, neither agree nor disagree, disagree that flooding is getting worse)					
Employment (in work, retired)	2	114	9.401	.009	0.56
Involvement in clean-up following flash flooding (yes, no)	2	144	12.849	.002	0.29
Perception of surface water flooding in Ryedale (agree, neither agree nor disagree, disagree that flooding is getting worse)					
Total number of floods recalled in 1990s and 2000s (scale variable, number of floods)	2	145	10.646*	.005	

Notes: Chi square test used unless specified; df=degrees of freedom; * Kruskal–Wallis test; ** Odds ratio calculated from the two 'extreme' categories of perception variables.

Sources: author (Jonathan Hopkins); questionnaire data.

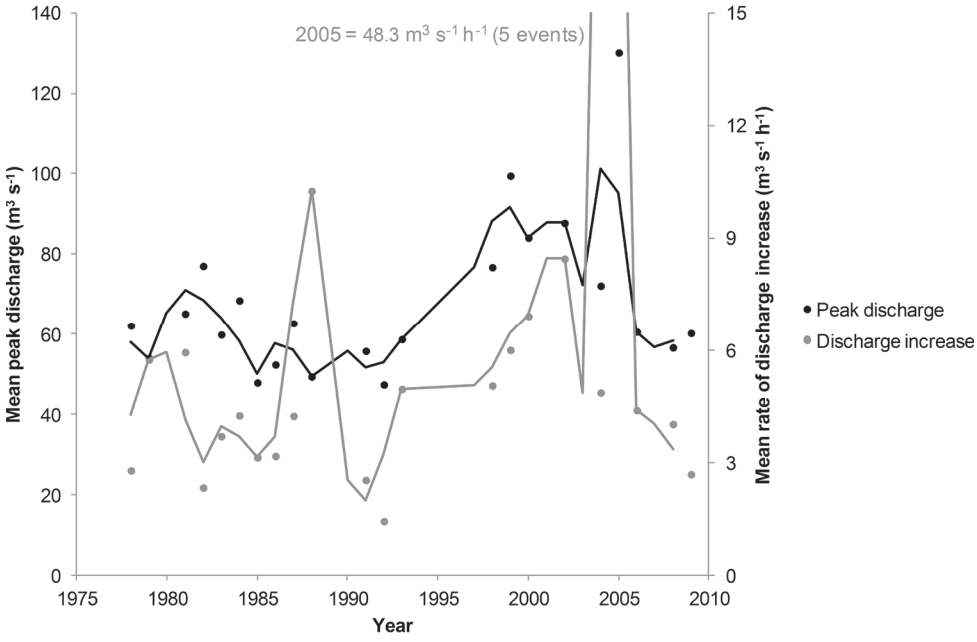
Perceptions of flash flooding and local flood risks: interview analysis

Insights gained from interviews suggest that an individual's knowledge of the history of flooding in upper Ryedale and Helmsley was an important factor influencing the perception of the flood hazard. Aside from the 2005 flash flood, the only other documented major river flood in upper Ryedale happened in 1754. This flood, which was of similar size to the 2005 flood (Wass, Faulkner, and Curini, 2008), destroyed several houses and bridges (John Pape's diary of 28 October 1754, cited in Cooper, 1887, p. 6, cited in McDonnell, 1963, p. 464). Some interviewees used the 1754 flood as a reference point, noting the apparent 250-year period between the events, and reasoned, therefore, that flood risks in the area were low as a result. This may reflect the noted 'lay' perception that floods occur in a regular and periodic way (Burton, Kates, and White, 1968) compounded by a misunderstanding of probability statistics (the '1-in-100-year' event). There were recollections of flooding in 1999 and 2000, likely to have been minor in extent at Helmsley. Furthermore, evidence from interviews in Helmsley suggests a high flow (but not overbank) in 2001–02. When a resident recalled river flooding in 2000 or other recent years, in addition to the flash flood of 2005, they tended to perceive a trend of increasing flooding. Finally, it is likely that some fluvial flooding occurred in upper Ryedale in the early 1930s and in 1947. Memories of the 1930s flood suggest that it was a slow-rising flood event: indeed an interviewee who recalled a 1930s flood event stated that he believed that future floods, if they happened, would also be slow-rising.

Another factor that may have influenced perceptions is the nature of other high flow events in upper Ryedale. The 2005 flash flood was a highly unusual event in the context of monitored river flows (August 1977–December 2009), with a peak discharge of 400 $m^3 s^{-1}$ (not measured directly; estimate by Wass, Faulkner, and Curini, 2008), far greater than the next highest peak (141 $m^3 s^{-1}$ on 3 November 2000). During the flash flood, the river rose from base level to peak in 1.75 hours, as compared with an average time (start of event to peak) of 16.9 hours for the 50 largest flow events on record. Extreme flood events can act in ways that are unexpected in comparison to smaller floods (Archer, Leesch, and Harwood, 2007). What is more, on an annual mean basis, the highest flow events in upper Ryedale had not become larger in magnitude or faster-rising (see Figure 4): following very large flows in 1999, 2000, and 2005, annual mean high flows had declined in extremity to earlier levels. This demonstrates the rarity of the 2005 flood, and may have contributed to views among residents that local flood risks were not increasing. Hence, an assessment of high flow events suggests that residents describing flash flooding as a 'one-off' are somewhat justified in doing so.

The contrast between the flood histories of upper Ryedale and Helmsley, and other areas in the region, had an important influence on flood risk perception. At the time of the fieldwork, upper Ryedale, in comparison to other nearby catchments, had experienced a much lower number of recent floods. Interviewees often stated that flood risks were higher, and/or flooding was more frequent, in other areas of the region. Questionnaire respondents were asked to rate the perceived likelihood of a

Figure 4. Changes to high flow events recorded at Broadway Foot, 1978–2009



Notes: based on 50 largest events. Figures are annual means and lines show two-year running averages.

Sources: author (Jonathan Hopkins); data provided by the Environment Agency, except the 2005 flash flood peak discharge (estimated by Wass, Faulkner, and Curini, 2008).

flood during the next 10 years in certain locations: 78.8 and 62.8 per cent respectively perceived the risk as high in central York and Pickering (n=137, n=137), whereas only 10 per cent perceived the risk as high for Upper Ryedale, and more than one-half (53 per cent) rated the risk as low (see Table 2). York (32 kilometres from Helmsley; see Figure 1a) is a lowland city located in a catchment that has experienced many floods (Environment Agency, 2010), and Pickering (19 kilometres from Helmsley; see Figure 1b) experienced flooding six times from 1993–2007 (Ryedale Flood Research Group, 2008a) and in 2008 (BBC News, 2008). Another nearby village, Sinnington (13 kilometres from Helmsley; see Figure 1b) had experienced relatively frequent flooding in the past (from 1880–1951) and flooding in 2002, 2007 (Ryedale Flood Research Group, 2008b), and 2008 (BBC News, 2008; Ryedale Flood Research Group, 2008b). Local views regarding a lack of flood defences in Pickering have been made clear (Brown, 2007); a petition on this issue attracted more than 4,000 signatures (Jeffels, 2008).

In this study, interviews found that, prior to the flash flood, residents (including those directly affected by flash flooding, and those not affected) predominantly: (i) did not consider their houses to be at risk of flooding; (ii) did not believe that a major flood like the 2005 flash flood could occur; and (iii) had not taken precautions to protect against flooding. These views often were related to individuals' past observations, experiences, and knowledge of local flooding. The extreme nature of the flash flood was unexpected. The restrictive nature of personal, local flood experience on risk

perception has been noted in the UK (Burningham, Fielding, and Thrush, 2008), and the limitations of past experience for flood responses have been found elsewhere (Burn, 1999). To cite the seminal observation of Kates (1962, p. 140): 'Men on flood plains appear to be very much prisoners of their experience'.

Discussion

To answer the question posed in the introduction, this research finds that the experience of infrequent flash flooding does not appear to be linked in a simple way to increased perception of flood risk. There is evidence that the physical risk of flash flooding is increasing across the UK (for instance, observed summer flood events). Furthermore, floods caused by intense rainfall are a common occurrence in upland areas, over longer time scales (Carling, 1986; McEwen and Werritty, 1988); similarly, Kundzewicz, Pińskwar, and Brakenridge (2013, p. 3) note that 'rare events occur on individual river reaches . . . somewhere in Europe fairly frequently'. However, the startling form of flash floods (see, for example, Gruntfest and Handmer, 2001) and their 'locally rare' nature (Creutin and Borga, 2003, p. 1453) mean that they are likely to be perceived as unusual if they do happen, based on local experiences and knowledge of flooding. Questionnaire analysis, comparing groups of respondents within this study, revealed that some experiences of flash flooding were associated with reduced risk perception.

Evidence of an increasing risk of flash floods was cited in the introduction to this paper. Crucially, the way that this has been experienced is a higher frequency of 'intensive' (as described by Burton, Kates, and White, 1993) hazards. Such events, within a local context, may not increase the perception of flood risk. It is difficult for residents to perceive and experience observed increases in summer flooding across the UK in areas where flooding is rare. The perception of a flash flood as a one-off event, when found in this study, constitutes a reasonable judgement in the context of personal knowledge of local floods: it is not the 'ostrich effect' of knowing ignorance of flood risk (described by Burningham, Fielding, and Thrush, 2008, p. 230). Other than the flash flood, most other recent experiences of flooding had been relatively minor (including surface water and drain flooding). The pattern of residents' flood knowledge often did not lead them to perceive that flash flooding would happen again, and river flow records clearly show the exceptional nature of the flash flood and do not suggest that high flows were becoming more extreme up to the time of the study.

Furthermore, nearby settlements (Pickering) had suffered flooding on a far more frequent basis than Helmsley and upper Ryedale. In the case study described in this paper, there is evidence of a 'prison of experience' (Kates, 1962), and further evidence that mental evaluations of future flood risks based on past experience (Green, Tunstall, and Fordham, 1991) may hold even after the occurrence and experience of an extreme flash flood.

There is evidence, though, of an influence of local flood knowledge, including the frequency of recent flood events recalled, on perception. There are also marked contrasts between the perceptions of an upland flash flood and perceptions of flooding in other areas (Pickering) that had experienced frequent (although more moderate) flooding.

Responses to hazards are associated with hazard frequency (Burton, Kates, and White, 1968; Harries, 2013). Types of indirect experience of flash flooding and knowledge of past floods appear to be the most important factors associated with perceived flood risks. It is notable that many demographic variables, including age and gender, were not found to be associated with perceptions, although significant associations between flood risk perceptions and socio-demographic variables have been found in other research (Miceli, Sotgiu, and Settanni, 2008; see Kellens, Terpstra, and De Maeyer, 2013 for review). However, if employment status (as defined in this study) is considered to act as a proxy for age, older residents typically had a higher perception of flood risk, reflecting similar findings in England and Wales (Burningham, Fielding, and Thrush, 2008). Further quantification of associations between age and risk perceptions could be particularly important in rural areas, as the older populations of rural areas (in comparison to urban areas) constitute a potential source of vulnerability (Twigger-Ross, 2005).

The insight that environmental issues are understood locally, with understanding driven by personal experience (Bickerstaff and Walker, 2001), influences both the perception of flash flood events and flood risks more generally, as well as perceptions of the causes of flooding. In this study, despite a generally widespread perception that summers had got wetter and local rainfall had become more intense, the poor maintenance of rivers was more frequently and strongly suggested by local residents as a factor influencing local flood risks, in comparison to climate change. This supports the findings of research in southern England: that 'flood victims view climate change and flooding as largely *separate issues*' (Whitmarsh, 2008, p. 368, original emphasis shown), with flooding perceived to be caused by things visible in the local environment (Whitmarsh, 2008). Other research has emphasised the importance of local observations and experience in the understanding of hazards (Irwin, Simmons, and Walker, 1999; Bickerstaff and Walker, 2001). Questionnaire and interview responses described a build-up of debris or vegetation, sometimes related to changes in management. Such views clearly result from reliable observations and personal experience, and these opinions are common in the UK after floods (see, for example, Environment Agency, 2007). Importantly, other research in North Yorkshire has found that the aggradation of sediment in an upland river (the River Wharfe near Buckden; see Figure 1a) influences changes in flooding (Lane et al., 2007; Raven et al., 2009), and modelling based on participatory research in Pickering found that vegetation and sediment build-up around river channels can increase flood risk (Whatmore, Ward, and Lane, 2008). It is debatable whether recent reports of public frustration regarding the lack of river dredging and blaming of the Environment Agency after floods in England (Merrill, 2014; Smith, 2014) suggest a tendency to blame others in the face of flood risk (Harries, 2013) or reflect views of 'ignorant

but arrogant experts' disregarding local knowledge and expertise (Wynne, 1992, p. 295). It is highly likely, though, that the experience of large floods in areas without recent or frequent experience of flooding will serve to compound these controversies. This study supports the recommendation of other research in the Ryedale district: that 'the concerns of those who could be affected by decisions to withdraw river maintenance are taken seriously' (Whatmore, Ward, and Lane, 2008, p. 9).

The need to inform the at-risk public with no or inadequate experience of flooding (Bradford et al., 2012) is a particularly relevant issue given the characteristics of flash floods. The most useful recommendations are for the greater distribution of local flood experience and knowledge (Bradford et al., 2012) and for what Burningham, Fielding, and Thrush (2008: 235) describe as 'making local people part of novel and interactive processes of awareness raising'. The use of a 'flood histories' approach, encouraging the sharing of personal flood knowledge within communities (McEwen et al., 2012), could be an excellent method with which to raise awareness; and a longer-term approach to flood education with strong community involvement is also described and recommended by Dufty (2008). Participatory processes can form a driver to 'encourage citizens to take more personal responsibility for protection and disaster preparedness' (Wachinger et al., 2013, p. 15), reflecting a key component of modern flood risk management (see, for example, White, Kingston, and Barker, 2010) and flood management strategy within England (Environment Agency and DEFRA, 2011). For flash floods, public communications should emphasise the need for public awareness of weather forecasts and rivers, and give advice for self-reliant public responses (Cave et al., 2009)—aspects that should be clearly included within engagement and participation.

In this study, some older residents possessed detailed knowledge of past flood events, including the cause and form of floods that occurred prior to the establishment of river flow monitoring. Where similar knowledge exists, it is a vital source of information for raising awareness of flooding within communities, which otherwise is unlikely to be recorded. Present national strategy emphasises property-level measures to respond to flood risk (see, for example, Environment Agency and DEFRA, 2011); however, without increases in flood awareness and perceptions of flood risk, it may be difficult to implement this effectively in upland catchments, as hazard perceptions may not be sufficient to lead to responses and extreme flash floods may be seen as one-off events.

Conclusion

This paper has explored public perceptions of an extreme flash flood event, and broader flood risk perceptions, within communities affected by flash flooding. It has shown that flash floods, when evaluated within a local context (which includes the important influence of personal flood knowledge), may not increase perceptions of flood risk. A tendency to link flood risks with poor river maintenance also was found, clearly reflecting recent controversies over flood management in England. Past literature

suggests a common association between flood experience and higher perception; crucially, though, past experience can also be unhelpful for the perception of large events (see, for example, Kates, 1962). Consequently, there is a clear need for further research on responses to extreme, rare, and dangerous flood events, in areas that otherwise have relatively low flood risks and/or have not experienced frequent flooding. This research has demonstrated that encouraging property-level responses to such events, and raising awareness of flood risks, may be very difficult in areas where perception remains imprisoned through a lack of direct experience.

Acknowledgements

The data used in this paper were collected as part of a PhD degree funded with an ESRC/NERC +3 Award (reference number ES/F009860/1); grant reference ES/I902147/1 also is acknowledged. Jeff Warburton acknowledges NERC grant support NE/D005744/1. This paper was partly funded by the Rural and Environment Science and Analytical Services Division of the Scottish Government. The authors would particularly like to thank residents who were interviewed and/or returned questionnaires, and wish to acknowledge the providers of data used in this project: the Environment Agency and the British Atmospheric Data Centre. Ordnance Survey Strategi® data was used in Figure 1. The authors would also like to thank the Cartographic Unit in the Department of Geography, Durham University, for producing the maps in Figure 1. Finally, Jonathan Hopkins acknowledges the comments and advice of Dr Bedru Balana.

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Endnotes

[1] http://www.ons.gov.uk/ons/index.html (last accessed on 24 November 2014). Crown copyright 2014. Figures cited below: adapted from data from the Office for National Statistics licensed under the Open Government Licence v.2.0.

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